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## **Evaluation of Human and Anthropomorphic Test Device Finite Element Models under Spaceflight Loading Conditions**

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**Introduction/Objective:** In an effort to develop occupant protection standards for future multi-purpose crew vehicles, the National Aeronautics and Space Administration (NASA) has looked to evaluate the test device for human occupant restraint with the modification kit (THOR-K) anthropomorphic test device (ATD) in relevant impact test scenarios. With the allowance and support of the National Highway Traffic Safety Administration, NASA has performed a series of sled impact tests on the latest developed THOR-K ATD. These tests were performed to match test conditions from human volunteer data previously collected by the U.S. Air Force. The objective of this study was to evaluate the THOR-K finite element (FE) model and the Total Human Model for Safety (THUMS) FE model with respect to the tests performed. These models were evaluated in spinal and frontal impacts against kinematic and kinetic data recorded in ATD and human testing.

**Methods:** The FE simulations were developed based on recorded pretest ATD/human position and sled acceleration pulses measured during testing. Predicted responses by both human and ATD models were compared to test data recorded under the same impact conditions. The kinematic responses of the models were quantitatively evaluated using the ISO-metric curve rating system. In addition, ATD injury criteria and human stress/strain data were calculated to evaluate the risk of injury predicted by the ATD and human model, respectively.

**Results:** Preliminary results show well-correlated response between both FE models and their physical counterparts. In addition, predicted ATD injury criteria and human model stress/strain values are shown to positively relate. Kinematic comparison between human and ATD models indicates promising biofidelic response, although a slightly stiffer response is observed within the ATD.

**Conclusion:** As a compliment to ATD testing, numerical simulation provides efficient means to assess vehicle safety throughout the design process and further improve the design of physical ATDs. The assessment of the THOR-K and THUMS FE models in a spaceflight testing condition is an essential first step to implementing these models in the computational evaluation of spacecraft occupant safety. Promising results suggest future use of these models in the aerospace field.